10/551900

\\pct

04 OCT 2005

DESCRIPTION

RARE EARTH OXIDE SUPERCONDUCTOR AND PROCESS FOR PRODUCING THE SAME

Technical Field

The present invention relates to an oxide superconductor and a process for producing the same and, more particularly, it relates to a tape-form rare earth oxide superconductor (RE superconductor) suitable for using in instruments such as superconducting magnets and superconducting cables and the improvement in a process for producing the same.

Background Art

Rare earth 123 superconductors (RE-123 superconductors) are excellent in magnetic field characteristics at liquid nitrogen temperature compared with Bi superconductors (Bi-Sr-Ca-Cu-O superconductors), therefore, it is possible to achieve a high critical current density (Jc) suitable for practical use under a high magnetic field. If a practical application of this wire material is successful, a production process without using silver, which is a noble metal, is possible as well as it has an excellent characteristic in a high temperature region, and liquid nitrogen can be used for a cooling medium thereby improving the cooling efficiency several tens-fold to several hundreds-fold; therefore, it is extremely advantageous from an economical standpoint. As a

result, it becomes possible to apply a superconducting wire material to an instrument to which it could not be conventionally applied from an economical standpoint, and the use and the market of superconducting instruments are expected to be expanded to a large extent.

The crystal system of RE-123 superconductors (particularly Y-123 superconductors with the molar ratio of Y:Ba:Cu = 1:2:3) is an orthorhombic crystal. Therefore, in order to exert the characteristics of the material in conducting characteristics, it is require to align not only the CuO planes of the crystal but also the in-plane crystal orientations. This is because only small misalignment of orientations generates bicrystal grain boundary and decreases the conducting characteristics.

A production process for fabricating a wire material while improving the in-plane orientation of the crystal in the above-mentioned Y-123 superconductor and aligning the directional property in the plane has the same constitution as that of a production process for a thin film. That is, by forming an intermediated layer in which the in-plane orientation and the directional property are improved on a tape-form metal substrate and using the crystal lattice of this intermediate layer as a template, the in-plane orientation and the directional property of the crystal in the Y-123 superconductor can be improved.

Further, the Jc of a superconductor depends on the crystallinity and the surface smoothness of an intermediate layer,

and it has been found that its characteristics vary sensitively according to the condition of the substrate to a large extent.

As a technique for producing a biaxially textured metal substrate in which an in-plane aligned intermediate layer is formed on the above-mentioned tape-form metal substrate, SOE (surface-oxidation epitaxy) method, ISD (inclined substrate deposition) method, IBAD (ion beam assisted deposition) method and RABiTS (rolling assisted biaxially textured substrate) method are known, and many reports in which Y-123 superconducting wire material with a Jc of more than 10^6 A/cm^2 is obtained by forming an intermediated layer in which the in-plane orientation and the directional property are improved on a non-textured or textured metal tape.

Among these, in the formation of an intermediate layer by the IBAD or RABiTS method, a vacuum process by a vapor phase method such as PLD (pulse laser deposition) method is used. In the IBAD method, a combination of Hastelloy/YSZ/Y_2O_3 is generally used as a biaxially textured metal substrate, on the other hand, in the RABiTS method, a combination of Ni/CeO_2/YSZ/CEO_2 or the like is generally used, and they have an advantage in that a dense and smooth intermediate layer film can be obtained (see, for example, Non-Patent Document 1).

As for materials of the above-mentioned intermediate layer, various investigations have been conducted, in particular, a CeO_2 intermediated layer has a good matching with the crystal lattice of a YBCO layer (Y-Ba-Cu-O superconducting layer) and has a small reactivity with the YBCO layer, therefore, it is known to be one

of the most superior intermediate layers, and lots of results are reported.

As described above, in the case where a YBCO layer is formed on a metal substrate, CeO_2 has an excellent characteristic as an intermediate layer, however, a CeO_2 film has a problem in that a crack is liable to occur due to such as the difference in thermal expansion with the metal substrate, and the film cannot be made thick. For example, in the RABiTS method, YSZ (yttria-stabilized zirconia) is interposed in the intermediate layer on the surface of a textured Ni substrate, and as shown in Fig. 2, it was necessary that a CeO_2 film (11), a YSZ layer (12) and a CeO_2 film (13) are sequentially formed on the surface of a textured Ni substrate (10), and a YBCO layer (14) is formed thereon.

[Non-Patent Document 1]

A. Goyal et al., Physica C, 357-360 (2001) 903

Disclosure of the invention

The present invention has been made in order to solve the above-mentioned problems, and an object of the present invention is to provide an RE superconductor in which an intermediate layer which prevents the occurrence of a crack and is excellent in crystallinity such as in-plane orientation and directional property and surface smoothness is formed on a metal substrate so that a rare earth oxide superconducting layer (RE superconducting layer) which is excellent in superconducting characteristics is formed on this

intermediate layer.

Another object of the present invention is to provide a process for producing an RE superconductor in which an intermediate layer which prevents the occurrence of a crack and is excellent in crystallinity such as in-plane orientation and directional property and surface smoothness is formed on a metal substrate by calcination under a pressure within a predetermined range at a temperature within a predetermined range so that an RE superconducting layer which is excellent in superconducting characteristics is formed on this intermediate layer.

Brief Description of the Drawings

Fig. 1 is a cross sectional view showing one embodiment of an RE superconductor of a first aspect of the present invention.

Fig. 2 is a cross-sectional view of a conventional rare earth oxide superconductor according to the RABiTS method.

Best Mode for Carrying Out the Invention

In order to solve the above problems, an RE superconductor, which is a first aspect of the present invention, is the one in which an intermediate layer (2) comprising a cerium oxide obtained by adding 5 to 90 mol%, in terms of the metal content, of one or two or more elements selected from rare earth elements Re (Re represents any one of elements of Y, Nd, Sm, Gd, Eu, Yb, Ho, Tm, Dy, La and Er) to cerium is formed on a surface of a metal substrate (1), and

an RE superconducting layer (3) is formed on this intermediate layer as shown in Fig. 1.

In addition, in order to solve the above problems, a process for producing an RE superconductor, which is a second aspect of the present invention, is the one in which an intermediate layer comprising a cerium oxide is formed by applying a mixture obtained by mixing 5 to 90 mol%, in terms of the metal content, of one or two or more elements selected from rare earth elements Re (Re represents any one of elements of Y, Nd, Sm, Gd, Eu, Yb, Ho, Tm, Dy, La and Er) with cerium on a surface of a metal substrate by a liquid phase process, and forming calcination at a temperature of 900°C or higher and lower than 1200°C under a reduced pressure of 0.1 Pa or higher and lower than atmospheric pressure, and then an RE superconducting layer is formed on this intermediate layer.

According to the RE superconductor of the present invention, by forming an intermediate layer on a metal substrate with a cerium oxide obtained by adding a predetermined amount of a specific rare earth element (Re), the occurrence of a crack in the intermediate layer can be prevented, and an intermediate layer excellent in crystallinity such as in-plane orientation and directional property as well as surface smoothness can be formed on a metal substrate. As a result, it becomes possible to form an RE superconducting layer excellent in superconducting characteristics on this intermediate layer.

In addition, according to a process for producing an RE

superconductor of the present invention, an intermediate layer comprising a cerium oxide is formed on a surface of a metal substrate by applying a mixture obtained by mixing a predetermined amount of one or two or more elements selected from specific Res with cerium by a liquid phase process, and performing calcination at a temperature within a predetermined range under a controlled atmosphere, therefore the occurrence of a crack in an intermediate layer can be prevented, and an intermediate layer excellent in crystallinity such as in-plane orientation and directional property as well as surface smoothness can be formed on a metal substrate. As a result, it becomes possible to form an RE superconducting layer excellent in superconducting characteristics on this intermediate layer.

In the RE superconductor of the present invention and the process for producing the same, an intermediate layer obtained by adding Re to cerium is formed on a surface of a metal substrate (under a controlled atmosphere), and an RE superconducting layer is formed on this intermediate layer. This intermediate layer is required to have a low reactivity with a superconductor, a small proportion of the difference in distance of the crystal lattice (misfit) and a function of preventing diffusion of metal elements in the substrate. From this point of view, as a crystal structure suitable for the intermediate layer, any crystal structure of a fluorite structure, a rare earth C-type structure and a pyrochlore structure is selected. In addition, since the occurrence of a crack that occurred in the

case of a monolayer of CeO_2 is suppressed by adding or including Re, the intermediate layer on a metal substrate can be a monolayer.

In the above case, the misfit between the lattice constant of the a-axis of Y-123 superconductor crystal (3.88 Å) and the above-mentioned oxide crystal lattice is 8% or less, however, this misfit varies depending on the composition, and if possible, it is preferred to be 1% or less.

The Re amount added to the intermediate layer in the first aspect as described above and the Re amount contained in the mixture in the second aspect is selected within the range from, in terms of the metal content, 5 to 90 mol%, preferably from 20 to 60 mol%.

It is because in the case where the Re content is low, the effect of preventing the occurrence of a crack is small, and when the Re content becomes high, the reactivity with YBCO layer and the metal substrate becomes high, thus the effect as an intermediate layer becomes small. In particular, the Re content exceeds 60 mol%, a different phase is liable to be deposited, whereby the surface smoothness is liable to be lost.

As the above-mentioned method of forming the intermediate layer in the first aspect, various film forming methods through a vapor phase process such as a physical vapor deposition method including PLD method, e-beam deposition, sputtering and the like, a chemical deposition method including chemical vapor deposition (CVD) and the like, IBAD method, which is a self-orientation process for an oxide and ISD method, or through a liquid phase process such

as MOD (metal organic deposition; deposition by thermal decomposition of organometallic salt) method can be used, however, it is preferred to use MOD method or PLD method in terms of the easiness of production and the production rate.

In addition, as the above-mentioned method of forming the intermediate layer in the second aspect, various film forming methods through a liquid phase process can be used, however, MOD method is adopted in terms of the easiness of production and the production rate.

The above-mentioned MOD method is known as a production method using a non-vacuum process. In the case of the present invention, after a mixed solution of metal organic acid salts of Ce and Re such as a trifluoroacetic acid salt (a TFA salt), an octylic acid salt and a naphthenic acid salt containing each metal element constituting the intermediate layer at a predetermined molar ratio is coated on a substrate, calcination is performed.

Calcination of the intermediate layer by the MOD method is performed under a reduced pressure of 0.1 or higher and less than atmospheric pressure (e.g., 800 Pa), and in particular, by performing calcination at a pressure ranging from 10 to 500 Pa, crystallization temperature can be decreased, whereby calcination of the intermediate layer at a low temperature of 1000°C or lower becomes possible. In the case of using a metal tape as a substrate, this is effective in terms of decreasing the rate of diffusing metal elements in the substrate into the inside of the intermediate layer.

In calcination at less than 0.1 Pa, random crystallization occurs before a film epitaxially grows, therefore, the orientation of the intermediate layer is significantly decreased. Further, a pressure ranging from 50 to 500 Pa is preferably adopted.

As for the calcination temperature of the intermediate layer, the calcination is performed at a temperature of 900°C or higher and lower than 1200°C. It is because in the case where the calcination temperature is lower than 900°C, it becomes difficult to obtain a biaxially textured film, and in the case where the calcination temperature is 1200°C or higher, a film is decomposed during the calcination, and it becomes difficult to obtain a desired oxide. In particular, the calcination temperature of the intermediate layer is preferably in the range from 950 to 1150°C.

As the metal substrate, a biaxially textured metal tape made of Ni, Ag, an alloy thereof such as Ni-V alloy or Ni-W alloy, or the like, a non-textured metal tape made of Ni, Ag or an alloy thereof, or a heat resistant alloy such as SUS, Hastelloy or Inconel can be used.

In the case where the intermediate layer is formed on the metal substrate, all the methods described as the method of forming the above-mentioned intermediate layer can be applied to a textured metal tape, and IBAD method and ISD method are applied to a non-textured metal tape in which the substrate itself does not have orientation. As mentioned above, in the case where the intermediate layer is formed by MOD method or PLD method, it is preferred to use a metal substrate

with high orientation as the metal substrate.

In addition, in the case where the intermediate layer is directly formed on the metal substrate made of Ni or a Ni alloy, as for the atmosphere during calcination, it is preferred to use a reducing gas atmosphere in which H_2 is added at 0.1 to 10% to an Ar and N_2 gas mixture. It is because in the case where a film is formed in an atmosphere having an H_2 concentration of less than 0.1%, NiO is produced on the Ni surface and the epitaxial growth of the intermediate layer film is significantly inhibited, and in the case where the H_2 concentration exceeds 10%, the reducing ability of the gas becomes too strong, therefore it becomes difficult to obtain a desired oxide.

As described above, an orientation controlling and diffusion preventing layer with thickness of 0.2 μm or less obtained by forming a film using a vapor phase process such as PLD method or a sputtering method can be provided between the intermediate layer formed by MOD method and the metal tape. Further, it is effective that the surface smoothness is improved by forming a CeO_2, Ce-Re-O film with thickness of 0.2 μm or less by PLD or a sputtering method as a CAP layer on the intermediate layer formed by MOD method.

In addition, the number of coating a precursor film of the intermediate layer film on the surface of the metal substrate by MOD method is by no means limited, and a technique in which a treatment of coating and preliminary calcination (drying) is performed plural times can be adopted for obtaining a desired film thickness.

As the method of forming a superconducting layer on the intermediate layer formed on the metal substrate as described above, various methods such as a film forming method through a vapor phase process such as a physical vapor deposition method including PLD method, e-beam deposition and the like, a chemical vapor deposition method including CVD method and the like, or through a liquid phase process such as MOD method in the same manner as for the intermediate layer can be used and the film can be formed.

In particular, among the above-mentioned methods of forming a superconducting layer, the intermediate layer according to the present invention is very effective in a method in which a precursor obtained by preliminary calcination of TFA (TFA-MOD method) or a precursor containing F in such as e-beam or PLD method (ex-situ method) is coated on the surface of a tape to form a film, and actual calcination of the obtained film is performed to form a YBCO film. In these processes, since F is contained in the precursor film and water vapor is used during calcination, HF is generated during the preliminary calcination and the actual calcination, therefore the acid resistance of the intermediate layer becomes the issue. However, the intermediate layer according to the present invention is a Ce-based oxide, therefore, it is excellent in acid resistance.

In the intermediate layer according to the present invention, since the occurrence of a crack can be prevented, the film can be made thick, and it is not necessary to form the intermediate layer with a multilayer structure interposing a YSZ layer as in the

above-mentioned RABiTS method, and an RE superconducting layer can be directly formed on a cerium oxide layer.

Hereunder, the present invention will be described with reference to Examples and Comparative Examples.

Examples 1 to 4

Mixed solutions of Ce-Gd, Ce-Y, Ce-Yb and Ce-Gd-Yb were prepared, respectively by using each naphthenic acid solution containing 0.2 mol/L of Ce, Gd, Y or Yb. This mixed solution was coated on a {100}<001> textured Ni substrate with a size of 10 mm x 5 mm by a spin coating method, whereby a coating film was formed. The rotating speed at this time was set to 3,000 rpm. The substrate coated with this coating film was subjected to a preliminary calcination heat treatment at 200°C for 15 minutes in the atmosphere, and further subjected to calcination at 1,000°C for 1 hour in an atmosphere of $Ar-H_2$ (2%), whereby an intermediate layer was formed.

Subsequently, a YBCO (Y-123) superconducting layer was formed on the above-mentioned intermediate layer by MOD method (TFA-MOD) using a trifluoroacetic acid salt. The superconducting layer was formed by applying a mixed solution of a trifluoroacetic acid salt containing each element of Y, Ba or Cu at a predetermined ratio to the intermediate layer, then subjecting the layer to a preliminary calcination heat treatment at 250°C for 15 hours in an oxygen atmosphere containing water vapor, and then subjecting the layer to calcination at 760 to 800°C for 1 to 3 hours in an oxygen atmosphere of $Ar-O_2$ (500 to 1,000 ppm) containing water vapor.

The in-plane orientation and presence or absence of the occurrence of a crack for the intermediate layer formed as described above, the orientation and presence or absence of the occurrence of a crack for the YBCO layer after YBCO film formation, the peak intensity and Jc for the intermediate layer are shown in Table 1 as well as the composition ratio of each mixed solution.

Table 1

		Composition ratio (mol%)				Intermediate layer		After YBCO film formation (TFA-MOD method)			
		Ce	Gd	Y	Yb	In-plane orientation	Presence or absence of a crack	Orientation of YBCO	Presence or absence of a crack	Peak intensity of intermediate layer (CPS)	Jc (MA/cm^2)
Example	1	55	45			good	absent	good	absent	11000	1.3
	2	70		30		good	absent	good	absent	10000	1
	3	60			40	good	absent	good	absent	8000	0.9
	4	70	25		5	good	absent	good	absent	11500	1.2
Comparative Example	1	100				good	present	good	present	3000	0.05
	2			100		good	absent	non	absent	500	0

Comparative Examples 1 to 2

An intermediate layer and a superconducting layer were formed on the textured Ni substrate in the same manner as in Example 1 except that a solution of naphthenic acid containing 0.2 mol/L of Ce or Y as a raw material solution of the intermediate layer was used. The results are shown in Table 1 in the same way.

Examples 5 to 8

An intermediate layer was formed on a {100}<001> textured Ni substrate by PLD method by using as a target each of sintered bodies of Ce-Gd-O, Ce-Y-O and Ce-Yb-O obtained by adding Gd, Y or Yb to CeO_2. The film forming conditions at this time were as follows: a Kr-F excimer laser at a wavelength of 248 nm was used, the temperature of the substrate was set from 500 to 800°C in an atmosphere of $Ar-H_2$ (1 to 4%), and the pressure during the film formation was set from 0.1 to 500 mTorr.

The formation of a superconducting layer on the intermediate layer was performed in the same manner as in Examples 1 to 4.

The in-plane orientation and presence or absence of the occurrence of a crack for the intermediate layer formed as described above, the orientation and presence or absence of the occurrence of a crack for the YBCO layer after YBCO film formation, the peak intensity and Jc for the intermediate layer are shown in Table 2 as well as the composition ratio of each sintered body.

Table 2

		Composition ratio (mol%)				Intermediate layer		After YBCO film formation (TFA-MOD method)			
		Ce	Gd	Y	Yb	In-plane orientation	Presence or absence of a crack	Orientation of YBCO	Presence or absence of a crack	Peak intensity of intermediate layer (CPS)	Jc (MA/cm^2)
Example	5	55	45			good	absent	good	absent	13000	1.7
	6	80		20		good	absent	good	absent	10000	1.2
	7	55			45	good	absent	good	absent	9500	1
	8	70	30			good	absent	good	absent	11500	1.5
Comparative Example	3	100				good	present	good	present	5000	0.05
	4			100		good	absent	non	absent	500	0

Comparative Examples 3 to 4

An intermediate layer and a superconducting layer were formed in the same manner as in Examples 5 to 8 except that CeO_2 or Y sintered body was used as a target.

The results are shown in Table 2 in the same way.

As is clear from the results of Examples and Comparative Examples above, in the RE superconductor obtained by forming an intermediate layer comprising a cerium oxide layer by MOD method or PLD method and then forming an RE superconducting layer on this intermediate layer by MOD method, a crack does not occur in the intermediate layer, the orientation of the intermediate layer and the superconducting layer is superior, and it shows a high Jc value. On the other hand, in the case where an oxide layer made of Ce or Y is used for an intermediate layer, due to the occurrence of a crack in the intermediate layer or the low orientation of the superconducting layer, either case results in showing an extremely low Jc value.

Examples 9 to 17

Each solution of an organometallic compound of Ce, Gd, Y or Yb at a metal concentration of 0.2 mol/L was prepared, and a mixed solution having a metal molar ratio shown in Table 3 was prepared. This mixed solution was coated on the textured Ni substrate with a size of 10 mm x 5 mm by a spin coating method, whereby a coating film was formed.

Table 3

	Material of Ce		Material of Gd		Material of Y		Material of Yb	
	Organic group	mol%	Organic group	Metal concentration mol%	Organic group	Metal concentration mol%	Organic group	Metal concentration mol%
Example 9	naphthenic acid	50	naphthenic acid	50				
10	octylic acid	60	naphthenic acid	20	octylic acid	20		
11	neodecanoic acid	40	neodecanoic acid	30	neodecanoic acid	15	neodecanoic acid	15
12	naphthenic acid	55	naphthenic acid	45				
13	naphthenic acid	20	naphthenic acid	80				
14	octylic acid	20	octylic acid	45			octylic acid	35
15	naphthenic acid	30			naphthenic acid	40	naphthenic acid	30
16	neodecanoic acid	50	neodecanoic acid	25			neodecanoic acid	25
17	octylic acid	50	octylic acid	50				
Comparative Example 5	naphthenic acid	100						
6			octylic acid	100				
7					octylic acid	100		
8	naphthenic acid	50	naphthenic acid	50				
9	octylic acid	50	naphthenic acid	50				

The rotating speed at this time was set to 3,000 rpm. The substrate with this coating film was subjected to a preliminary calcination heat treatment, and then subjected to calcination at a temperature ranging from 900 to 1150°C in an atmosphere of $Ar-H_2$ (2%) at a pressure ranging from 10 to 500 Pa, whereby an intermediate layer with a film thickness of 100 to 600 nm was formed on the textured Ni substrate. The calcination temperature, the pressure during calcination and the film thickness of each Example are shown in Table 4.

Table 4

	Calcination temperature (°C)	Pressure during calcination (Pa)	Film thickness (nm)	CAP layer	Intermediate layer		Peak intensity of intermediate layer (CPS)		Jc (MA/cm^2)
					Orientation (%)	Presence or absence of a crack	During production	After YBCO film formation	
Example 9	1000	100	200	absent	98	absent	5500	5200	1.8
10	1050	50	200	absent	95	absent	5000	4800	1.2
11	950	200	600	present	90	absent	5800	5500	1
12	1100	500	300	absent	97	absent	6500	6300	1.9
13	1050	30	400	present	93	absent	4800	4200	0.9
14	1000	10	400	present	90	absent	4500	4400	1
15	900	500	500	absent	85	absent	4800	4150	0.9
16	1150	100	150	absent	94	absent	5800	5800	1.1
17	1000	80	100	absent	99	absent	7000	6950	1.1
Comparative Example 5a	1000	1.01E+05	100	absent	99	present	4000	400	0
5b	1000	100	100	absent	97	present	4500	500	0
6	1100	1.01E+05	300	absent	92	absent	3000	750	0
7	1050	100	200	absent	95	absent	2500	300	0
8a	800	150	200	absent	90	absent	2200	800	0
8b	1000	1.01E+05	200	absent	96	absent	2500	950	0
8c	1000	1.01E+05	200	present	99	absent	2500	1100	0.2
9	1200	100	200	absent	0	absent	200	150	0

In Table 4, 1.01E+0.5 Pa means 1.01 x 10^5 Pa, namely, indicates the atmospheric pressure.

Subsequently, a YBCO (Y-123) superconducting layer was formed on the above-mentioned intermediate layer by MOD method (TFA-MOD) using a trifluoroacetic acid salt.

The superconducting layer was formed by applying a mixed solution of a trifluoroacetic acid salt containing each element of Y, Ba or Cu at a predetermined ratio to the intermediate layer, then subjecting the layer to a preliminary calcination heat treatment at 250°C for 15 hours in an oxygen atmosphere containing water vapor, and then subjecting the layer to calcination at 740 to 800°C for 1 to 3 hours in an oxygen atmosphere of Ar-O_2 (500 to 1,000 ppm) containing water vapor.

Incidentally, in the above-mentioned Examples, the one having a CAP layer on the intermediate layer was obtained by forming a CeO_2 film (with a film thickness of 0.05 μm) by PLD method on the intermediate layer formed by MOD method.

The in-plane orientation and presence or absence of the occurrence of a crack for the intermediate layer of the Re superconductor produced as described above, the peak intensity, and Jc for the intermediate layer are shown in Table 4 at the same time.

As is cleat from the results of Examples above, according to the process of the present invention, the occurrence of a crack is not observed in the intermediate layer and a good orientation is obtained, which does not depend on the type of organic acid salt

used as a raw material.

In addition, the change in peak intensities of the intermediate layer due to YBCO film formation is hardly observed, the YBCO layer and the intermediate layer are chemically stable, and it is clear that it can be applied as a reaction preventing layer. Further, as for the Jc value, a high value can be obtained under all the conditions.

Comparative Examples 5 to 9

Each solution of an organometallic compound of Ce, Gd or Y at a metal concentration of 0.2 mol/L was prepared, and a coating film was formed on the textured Ni substrate in the same manner as in Examples 9 to 17 using the respective solutions of organometallic compounds of Ce, Gd and Y and a mixed solution of Ce-Gd as shown in Table 3.

Thereafter, in the same manner as in the above-mentioned Examples, a preliminary calcination heat treatment and calcination were performed for the substrate with this coating film, whereby an intermediate layer with a film thickness of 100 to 300 nm was formed on the textured Ni substrate. The calcination temperature, the pressure during calcinations, and the film thickness of each Comparative Example are shown in Table 4.

Subsequently, in the same manner as in Examples, a YBCO (Y-123) superconducting layer was formed on the above-mentioned intermediate layer by TFA-MOD method.

The in-plane orientation and presence or absence of the

occurrence of a crack for the intermediate layer of the RE superconductor produced as described above, the peak intensity, and Jc for the intermediate layer are shown in Table 4 at the same time.

As is clear from the results of Comparative Examples above, in the CeO_2 monolayer (Comparative Example 5), a crack occurs in the intermediate layer, and the peak intensity of the intermediate layer is significantly decreased after YBCO film formation, therefore, it does not show a Jc value.

In addition, as for the Gd_2O_3 monolayer (Comparative Example 6) or the Y_2O_3 monolayer (Comparative Example 7), the intermediate layer and the preliminary calcined YBCO film were reacted during the actual calcination of YBCO and the YBCO film does not grow, and the peak of the intermediate layer is decreased to a large extent, therefore, it does not show a Jc value.

Further, when the calcination temperature of the intermediate layer or the pressure during calcination deviates from the range of the present invention (Comparative Examples 5a, 6, 8b and 8c), the intermediate layer does not grow up to the surface, and YBCO is not aligned, therefore it does not show a Jc value or it will be an extremely low value. When the calcination temperature of the intermediate layer is 1200°C (Comparative Example 9), the intermediate layer itself is decomposed, and it does not show a Jc value.

Industrial Applicability

A rare earth oxide superconductor and a process for producing the same according to present invention is useful in a tape-form rare earth oxide superconductor suitable for using in instruments such as superconducting magnets and superconducting cables.